



# ***Emerging Transmission Technologies to Increase Capacity, Enhance Stability and Mitigate Congestion***

Presented to  
***California Energy Commission***  
***Staff Workshop: Emerging Technologies***  
***for the Integration of Renewables***

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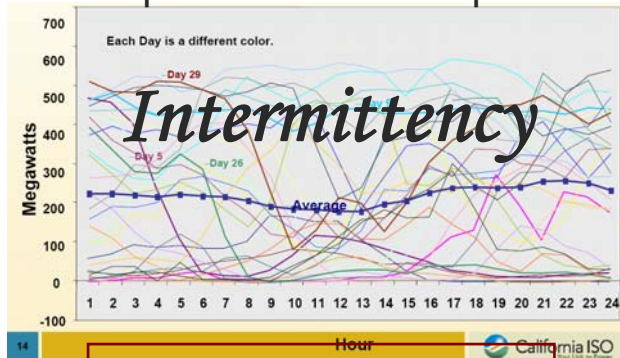


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# The Saga of Renewable & Transmission Integration



Tehachapi Wind Generation - April 2005



Accommodate  
Renewable's Unique  
Behaviors

Provide Access

Renewable  
Power Plant

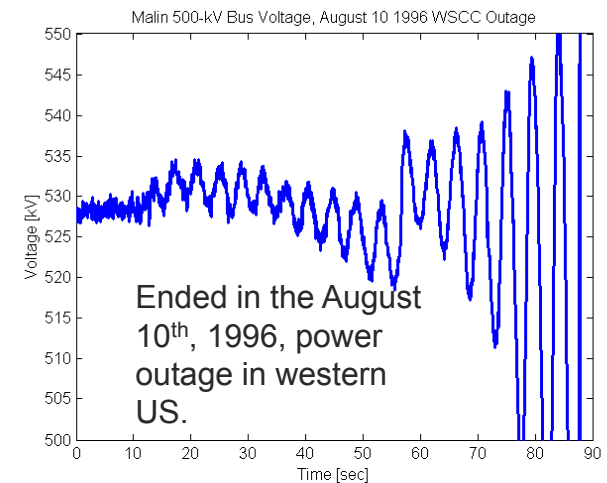


Thermal Limits

Increase Capacity

**Instability Deratings**

**Example of North – South Oscillation**

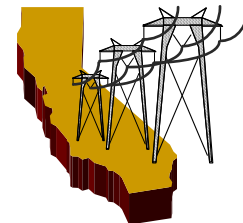


# To fulfill its renewable integration mission,...



...transmission must achieve three broad objectives:

1. Provide physical access for each new power plant,
2. Reliably accommodate any unique renewable generator behaviors, and
3. Increase its power carrying capacity to handle the additional electric power flows.



# How to Meet the Three Objectives at 33%

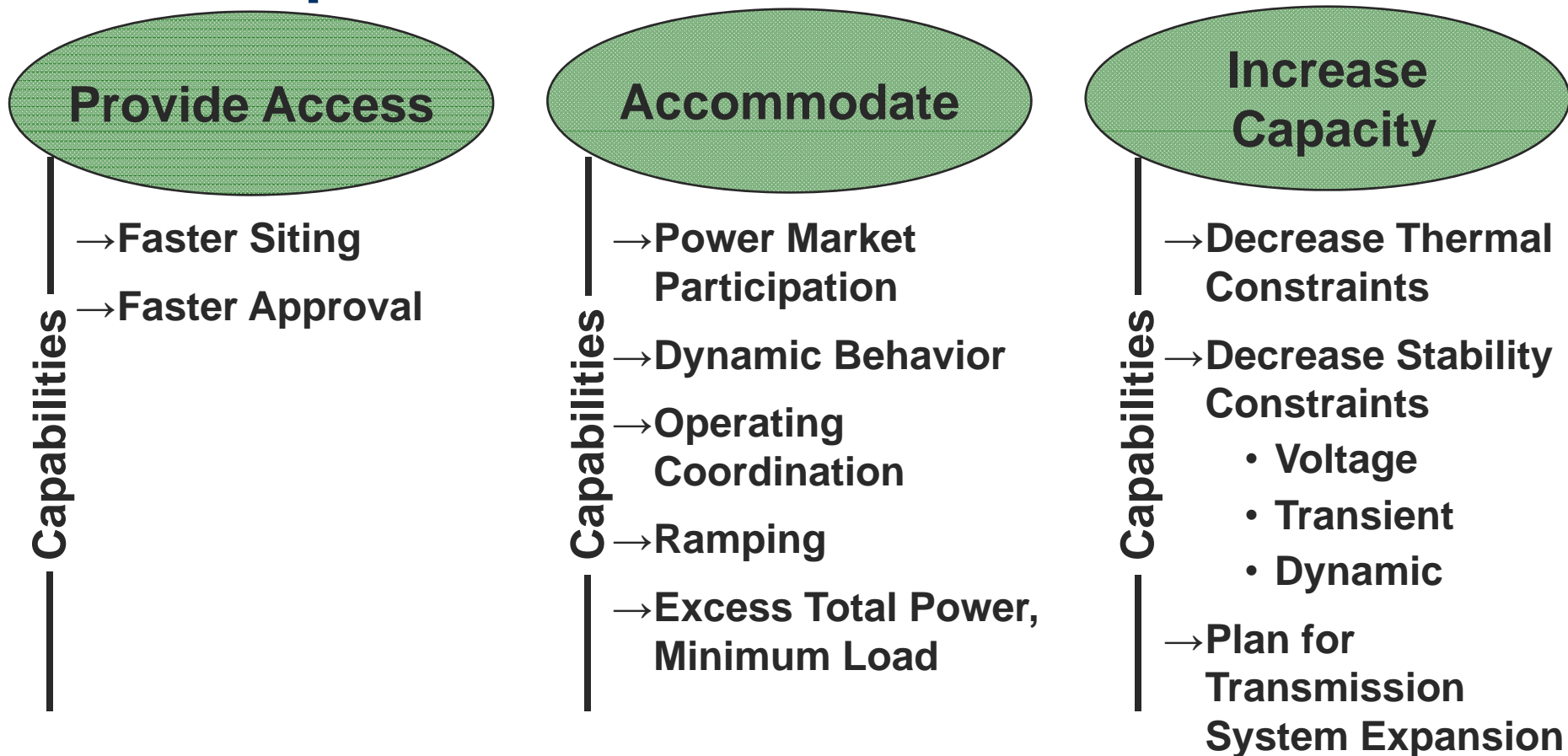


- Traditional “Build” solutions, i.e., investments in wires, towers and power plants, can’t do it alone.
- New transmission technologies at a minimum can make renewable integration easier and less costly.
- New technologies can endow transmission with improved and new capabilities...

# To accomplish its 3 objectives,...



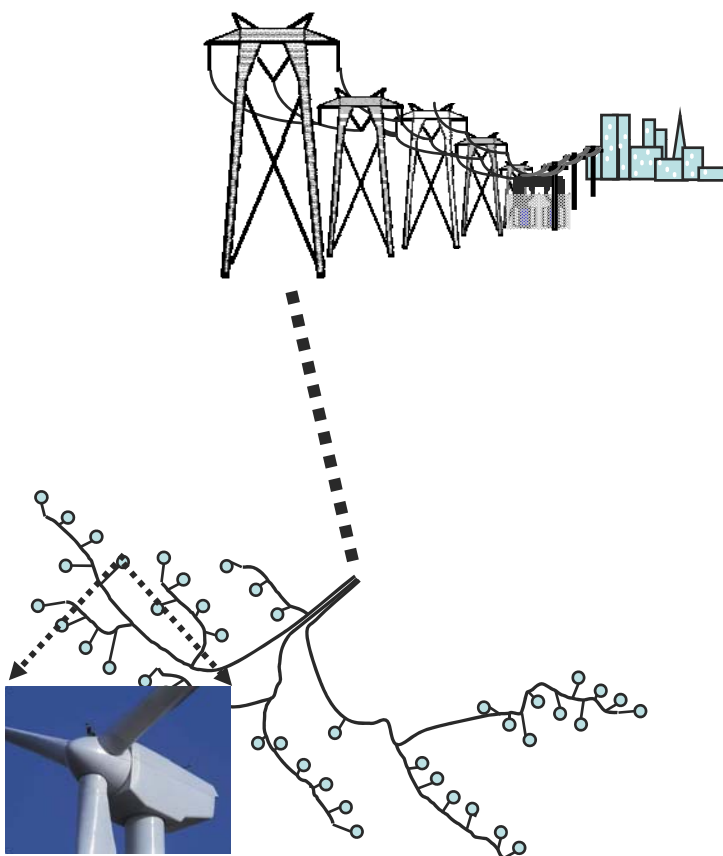
## ...transmission must obtain improved and new capabilities.



# Some New Technologies to Provide Faster Access for New Renewable Plants...



... by putting new transmission lines in a better light.



- Underground Transmission
- High Voltage Direct Current
- Advanced Transmission Line Conductors
- Engineered Compact Designs
- Web-based Interactive Stakeholder Siting Tools
- Cost Allocation and Strategic Benefit Analysis Tools
- Distributed Renewables

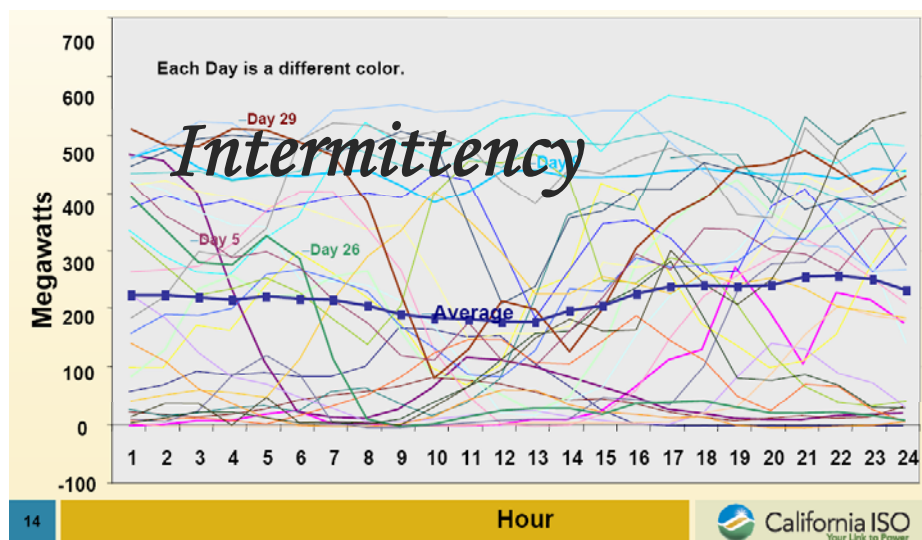


# Some New Technologies to Accommodate Unique Renewable Generator Behaviors...



...through a smarter and more flexible grid.

Tehachapi Wind Generation - April 2005

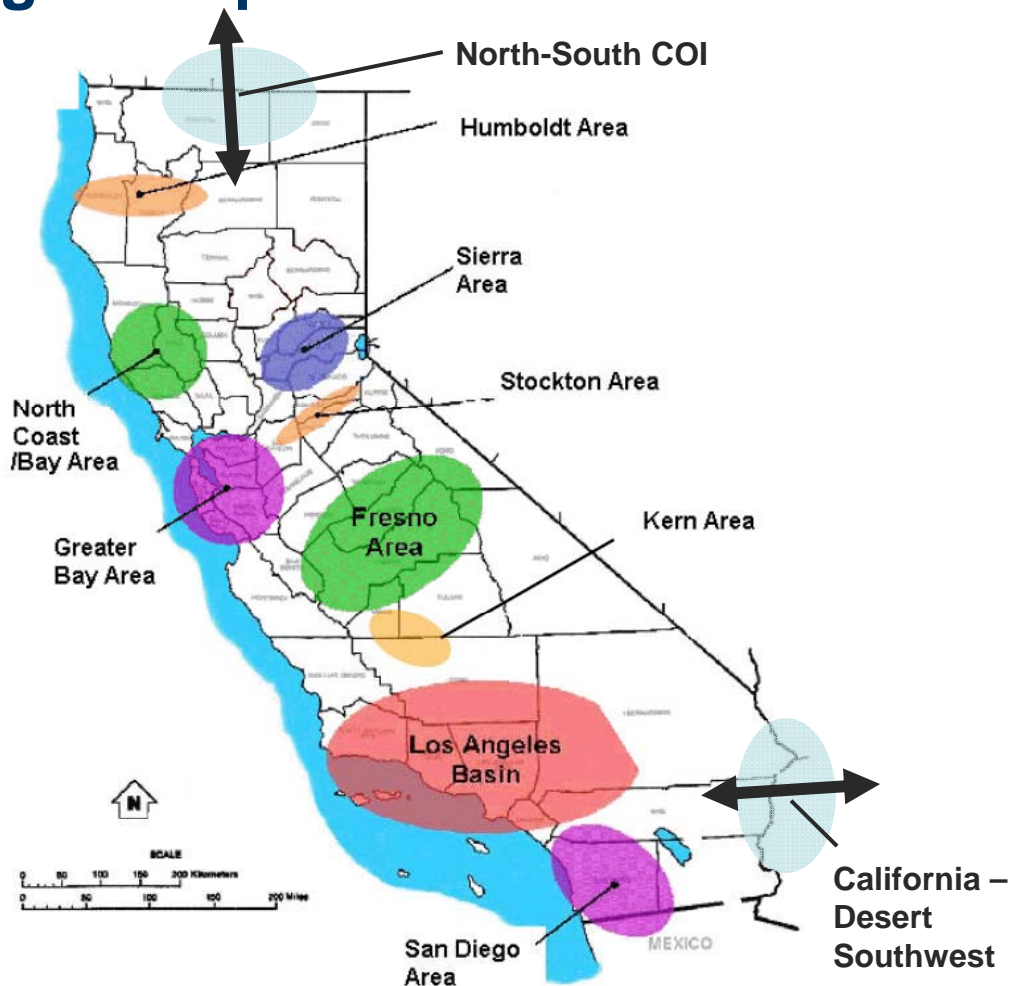


- Energy Storage & Intelligent Agent
- Solar and Wind Forecasting Tools
- Synchrophasor Measurement
- Power Flow Control (spatial)
- Demand Response
- Distributed Generation
- Generator and Load Modeling
- Statistical and Probabilistic Forecasting Tools
- Advanced Intelligent Protection Systems

# Some New Technologies for Increased Transmission *Capacity*...



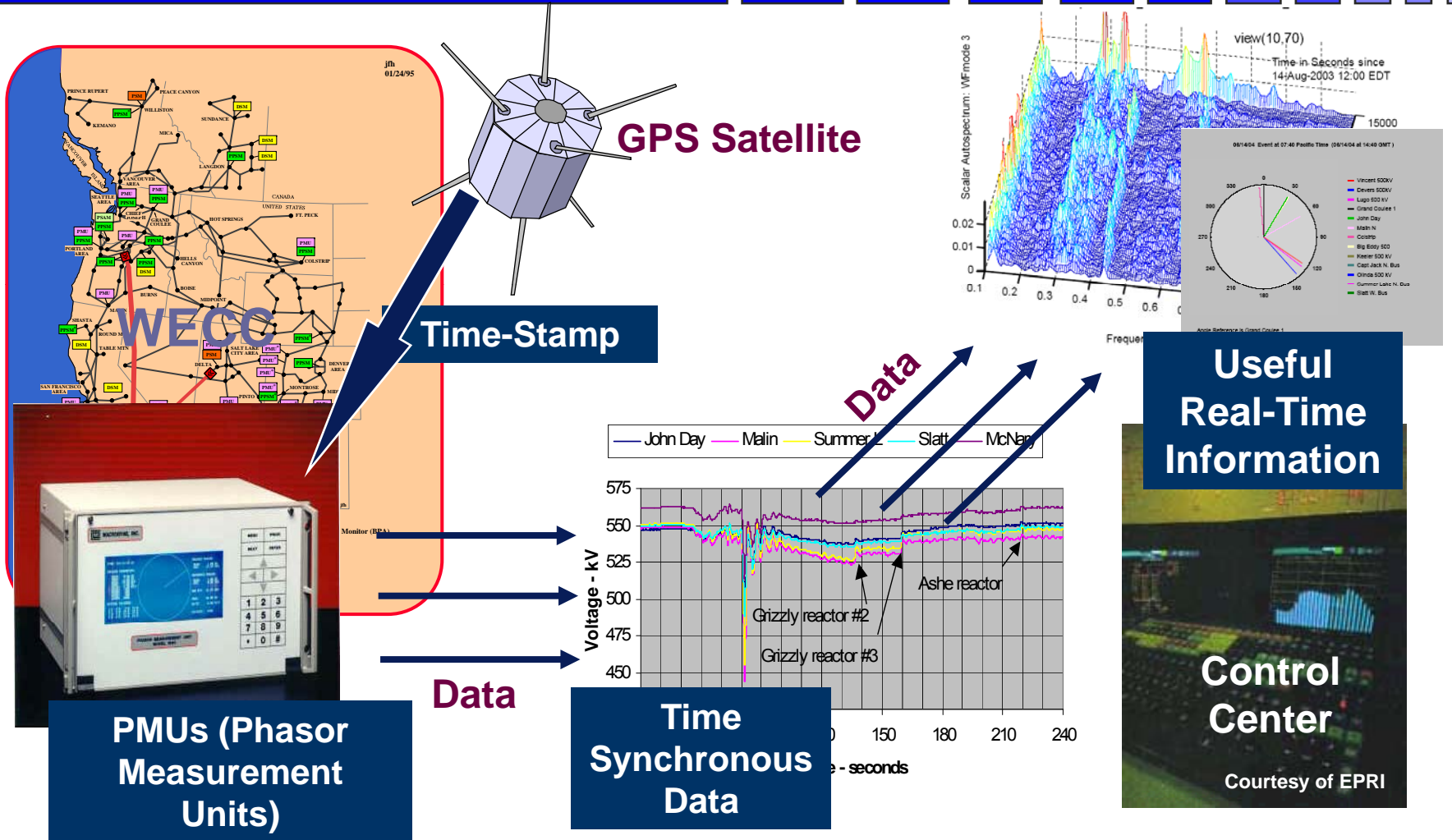
... by fine-tuning the grid for greater power flow.



- Dynamic Thermal Ratings
- Real-Time System Operations (synchrophasors & applications)
- Power Flow Control (spatial)
- Energy Storage
- Advanced Transmission Line Conductors
- High Voltage Direct Current
- Distributed Generation
- Statistical & Probabilistic Analysis & Planning Tools
- Advanced Intelligent Protection Systems



# Synchrophasor Measurement – The Heart of the Smart Grid Transmission



Ultimately, Smart Grid required for maximum renewables deployment.